Enhancing CalCOFI's Contributions to Fishery Science

presented by

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CalCOFI will continue to make substantial contributions to fishery science and thereby support management of California Current species regardless if any of the enhancements I discuss today are ever realized. On a routine basis, the ichthyoplankton data are used in stock assessment models for anchovy, sardine, Pacific mackerel, bocaccio, blackgill rockfish, and cowcod. Others will be added to this list as additional species taken in the surveys are assessed. Hundreds of species are identified in the surveys, about 20% of which are economically important, but only relatively few have been assessed. The historical record of larval abundance is particularly important for stock assessments because it is the only fishery-independent information that exists before the early 1980's and the only one that extends to present time. Without such information, fishery scientists knowledge of prior abundance is largely limited to the last decades, a very serious handicap for a proper assessment. In addition to these routine annual contributions to fisheries, researchers using CalCOFI data have made many important contributions to the understanding of the dynamics of marine populations and ocean processes in the California Current which are documented in more than a thousand publications. However, my job today is not to list the laurels of the last 50 years of CalCOFI, nor expound on the value of maintaining a time series, rather I wish to consider how our fine collaboration could be enhanced to further benefit fishery science. I am going to talk briefly on seven somewhat overlapping enhancement ideas: 1)monitoring a larger fraction of populations; 2) larval transport budgets for topographically linked species; 3) integration of CalCOFI surveys with satellite oceanography; 4) advanced sampling technology; 5) prerecruit sampling and recruitment indices; 6) migration and movement models; and 7) ecosystem management. This short list of ideas was generated in discussions with my colleagues at the SWFSC.

1) Monitoring a larger fraction of populations

CalCOFI surveys are a pelagic ecosystem monitoring program which currently monitors about 20% (94,000 nm^2) of the California Current System (CC S) Pelagic Ecosystem. While quarterly monitoring a 94,000 nm^2 piece of ocean for over 50 years is an unparalleled accomplishment in ocean monitoring, the population boundaries of no species are contained within the 94,000 nm$^{2.}$ Fishery management is based on the dynamics of entire stocks not pieces of them, hence no better enhancement of an ecosystem monitoring program exists than to expand its boundaries to cover a greater fraction of target populations. The more extensive the coverage the more representative the measurements become of the population, and hence the more valuable to fisheries assessment work. A northern expansion of the present pattern to San Francisco is the preferred first step in my opinion for three reasons: presently IMECOCal is covering the area south of the present pattern; the highest concentrations of eggs and larvae of key species including sardine, hake and many commercial important rockfishes are north of the present pattern; and the standard CalCOFI stations in this area were occupied prior to

1985; thus if they were reoccupied a 1950-present time series would be generated. In my opinion, first priority should be given to reoccupying the northern stations eliminated from the pattern since 1984, and second priority, to increasing plankton sampling. Both actions would benefit management of near shore species to be managed by California under the new Marine Life Management Act. Linking to the past time series is clearly more important from the standpoint of stock assessment than improving the precision of present time series by taking more inshore stations.

2) Larval Transport budgets for topographically linked species.

An important fishery science issue is the extent that the fishery resources of the southern California Bight are sustained by local production, and the extent they are maintained by larvae transported from the north (Central California coast) and from the south (Baja California, Mexico). The fishes in the Southern California Bight being exposed to high fishing effort because they are adjacent to heavily populated southern California may be strongly dependent on recruits from these less populated coastlines. The rocky shore fishes; particularly various rockfishes, sheepshead, cabezon, and others; appear to be seriously depleted in the Southern California Bight. A larval transport budget for topographically linked species would greatly improve our understanding of the functioning and utility of marine reserves designed to rebuild these species. An important test case is the 43, 000 nm^2 reserve, an area closed to fishing for cowcod, in the Bight (Cowcod Conservation Area) which was implemented as a key element of the rebuilding plan for this over fished stock. To develop a larval budget for the Bight would require augmenting existing surveys by increasing near shore sampling using a sampling pattern that would also measure Bight circulation. Input from large scale climate dynamics also may be required.

3) Integration of CalCOFI surveys with Satellite oceanography.

Satellites measure at the population scale but most ocean surveys, including CalCOFI, cannot afford to do so. From space we observe ocean processes in the California Current that may help resolve some of the fundamental questions related to recruitment, decadal changes in fish productivity, and larval transport. Mesoscale anticyclonic eddies roughly 150 km diameter (revealed from TOPEX altimeter data), can persist for months. They occur adjacent to sardine spawning habitats and may provide a nursery habitat for young sardines and other fishes in Central California during a critical part of their life history. This runs counter to the early life history idea that larvae swept offshore by currents are lost to the population. It seems possible that the differences we see in productivity among different fish stocks in cold and warm water regimens may be related to the prevalence or the persistence of such eddies. Remote sensing also reveals patterns in spawning habitat selection by sardine, where spawning is associated with offshore jets and this may also play a role in early survival. Neither the mesoscale eddies nor the jets can be consistently resolved in the coarse CalCOFI grid, nor is the grid large enough to capture these features in their entirety. On the other hand, CalCOFI is the best way we have of providing ground truth for these remotely detected features, but we must find someway to blend satellite and survey approaches so that we can determine the effect of such mesoscale features on the dynamics of populations.

4) Prerecruit sampling and recruitment indices.

CalCOFI surveys since their inception have involved sampling the early life stages of fishes using standard plankton nets. We now know that the eggs and early larval stages captured by such nets are good indices of adult spawning biomass but the abundance of these early life stages are not correlated with the abundance of the recruits. Clearly, to understand the recruitment process in fishes also requires monitoring the animals at a life stage where the year class is manifest. In addition to advancing understanding of the recruitment process, prerecruit sampling would provide indices of recruitment, a valuable input for fishery assessment models. Such indices are particularly valuable for short-lived species which require an annual assessment. Thus, the fishery contribution of CalCOFI surveys could be greatly enhanced if prerecruit sampling using $10m^2$ MOCNESS or trawl or other gear were added to the annual surveys during summer or fall cruises. The NMFS Laboratory at Santa Cruz maintains a time series for prerecruit rockfishes taken in Central California using a pelagic trawl which makes valuable contributions to rockfish assessments. We have been evaluating the $10m^2$ MOCNESS as a prerecruit sampler in the Bight for the last two years. Thus, prerecruit indices would be a valuable enhancement to CalCOFI surveys but they could not be added to the present survey without giving up other sampling activities and thereby violating the time series to some extent.

5) Advanced sampling technology.

Improvements in the effectiveness of shipboard monitoring of the ocean would be an important contribution to fisheries' science and to marine science in general. Most ocean programs suffer under the burden of the high cost of operating oceanographic research vessels. Technical advances that would increase the spatial and temporal coverage of present surveys or the effectiveness or efficiency of present samplers are sorely needed. This is especially important if biological oceanography were to shift from the site intensive scale to the population scale studies needed for resource and ecosystem based management. CalCOFI surveys are an ideal test bed for evaluating new techniques for monitoring pelagic ecosystems because of the long time series of measurements, wide variety of variables routinely measured, and consistent survey design. Four important areas for technical advances are: increasing the use of underway monitoring; automatic molecular identification of taxa; development of adaptive sampling strategies; and incorporation of remotely sensed information (discussed above).

<u>Underway monitoring</u>: The concept here is to transform fixed grid sampling to continuous monitoring, thereby providing higher spatial resolution needed for the mesoscale features and increase coverage because of time savings. The advanced underway instruments already exist (Seasoar, towed acoustics, ADCP, OPC, CUFES and expendable oceanographic probes) and a few need to be developed (underway micronekton samplers, and automatic molecular species identifier). The challenge is to find a way to merge known arrays of these instruments into a complementary underway monitoring system and to develop algorithms for data reduction and synthesis.
<u>Automatic molecular species identifier</u>: Presently, eggs and larvae must be removed from preserved plankton collections and species identified individually. In a few groups, notably certain species of rockfishes of substantial economic importance, some of the

larvae are so similar to each other that they will never be identified using light microscopy. Automatic identification using molecular methods would constitute a major advance by rapidly identifying the confounded species in these confounded groups as well as providing machines that may be able to replace humans over the long term in routine identifications. Driven by biomedical needs, the rapid advancing field of genetic array technology allows several thousand single stranded gene sequences (species specific diagnostic markers) to be bound to glass slides or silicon chips and then washed with unknown ichthyoplankton DNA. Matches are detected by fluorescence complementation binding and automatic detection. A first step in automating identification would be to apply this existing technology to CalCOFI ichthyoplankton.

<u>Underway prerecruit sampler</u>: Fishery independent census of prerecruits and adult pelagic fishes is an inaccurate and costly measurement, yet a fundamental one from the standpoint of population dynamics. What is needed is a continuous underway species specific census. One way of doing this is to develop an integrating acoustic/range-gated imaging lidar system as proposed by a NMFS-OAR working group in 1999. The lidar component would solve the current problems with acoustic measurements (inability to accurately identify species or accurately estimate size) while the integrated acoustic sensor will be used to provide abundance estimates from greater water volumes that can be obtained using lidar alone.

<u>Adaptive Sampling</u>: Estimating the density of eggs and larvae of key species as well as their aerial extent is a routine objective of CalCOFI cruises. The distributions of eggs and larvae of many of the species are extremely patchy. Hence, for the same level of effort precision can be increased if an adaptive sampling strategy is employed where in more samples are taken systematically when high concentrations are found. The challenge for CalCOFI for the future is how to adapt this strategy to that of an ecosystem survey while preserving a time series of abundance.

6) Migration or Movement models.

The two greatest fisheries stocks of the CCS, sardine and hake, carry out extensive coastal movements annually. Understanding the timing and extent of these annual movements is an important element of their management. In sardine, age and size composition data is hopelessly confounded because of our ignorance of their movements, and this causes major uncertainties in modeling their dynamics. Annual movements of hake affect their availability to the fishery dynamics and catch allocations between Canadian and U.S. fisheries. The movements and locations of spawning habitats of these species are greatly affected by El Niño and other changes in ocean climate. The coastwide distribution of their food resources (plankton) is a primary driving force affecting their movements, about which we have little information. A broader coast-wide monitoring program is necessary to improve our understanding of coast wide movements, and in particular the distribution of planktonic forage. Expansion of CalCOFI to a coast wide monitoring network maintained by a consortium of organizations is a possibility. Another approach, are coastwide aerial surveys to measure plankton concentration in the upper 30m using lidar, water temperature vertical profiles, surface salinity and ocean color.

7) Ecosystem Management:

Before long the Magnuson-Stevens Fishery Conservation and Management Act will be amended to include provisions for ecosystem-based management of federally managed stocks. Many of us in fishery work are a little uncertain of how effective ecosystem-based management will be nor what ecosystem control rules might be used for particular fisheries or ecosystems. Will it be just another paper exercise for over-taxed analysts or will positive benefits accrue? At the minimum it seems likely that Fisheries Ecosystem Plans will require addressing issues of bycatch, effects of gear on habitat, making harvest rates accountable for potential ecosystem effects of removals, and estimating total removals of all species. Most modern fishery management plans already include most of these elements to some degree. To break new ground, an ecosystem monitoring program must be in place, and indices of ecosystem health must be developed as targets for management. Monitoring programs are essential because they are needed to separate the effects of fishery policy from environmental factors and thereby determine effectiveness. Clearly, a challenge exists for CalCOFI in the realm of ecosystem-based management. Can we use 50 years of ecosystem monitoring to develop indices of ecosystem health? We monitor the abundance of hundreds of species but about only 20% are fished. Can the relative abundances of the fished and unfished components be used to express ecosystem effects of removals, taking environmental effects into account? Are we spending our survey dollars in the most effective way to answer pelagic ecosystem questions? Unfortunately, the intellectual base of the CalCOFI program is largely observational; ecological modeling has not been a consistent element of the program nor does the expertise exist in the immediate CalCOFI family of scientists. Ways need to be found to bridge this gap, and build an ecosystem modeling into the program of the future.

Conclusion.

Since the demise of the grand monthly pattern (1949-1969), discussions of enhancement of CalCOFI surveys, regardless of the audience, invariably lead to similar recommendations — expand the spacial and temporal coverage of the surveys and sample more intensively nearshore while continuing to occupy the present stations. In short, many of the most valuable new contributions to science or to fisheries work from the CalCOFI surveys require spending additional funds to increase the number and kinds of observations. My short survey of ideas was no exception to this rule.

Support for an expanded observation system will require the development of a new vision of monitoring the pelagic ecosystem of the California Current, built upon the solid base of the CalCOFI time series, but involving more organizations, organized under a new name, providing a wider array of public benefits, and a much greater portion of the CCS under direct observation. Perhaps the session objective “enhancing the contributions of CalCOFI surveys” needs to be redefined as “building a coast wide consortium for monitoring the California Current pelagic ecosystem.” In other words, expanded coverage requires new partners in coastal monitoring, a new name, while preserving the most valuable features of CalCOFI, maintenance of biological and physical time series, joint venture between academic and resource agencies, and a blending of applied and long range science goals.